owing to the spin filter effect, the film will be quite useless in practical applications. It is understood from the data noted above that the simple spin filter effect could not realize spin valve films having an ultra-thin free layer and exhibiting high MR ratio.

Comparative Case 3: JP-A 10-261209

5 nanometer Ta/3 nm Cu/1 nanometer Ta/5 nm NiFe/2.5 nm Cu/2.5 nm Co/10 nm FeMn/5 nanometer Ta

(3)

In the film (3) disclosed in JP-A 10-261209, the Cu shunt layer disposed adjacent to the free layer via Ta therebetween is, being different from the layer as intended for the spin filter effect for the MR ratio as in USP No. 5,422,591 of Comparative Case 2, intended for stabilizing the asymmetry by reducing the current magnetic field Hcu and by retarding the bias point fluctuation owing to sense current. This idea will be effective in the region where the free layer is relatively thick as in the film (3), but is quite ineffective in the case of ultra-thin free layers to which the present invention is directed, in view of the bias point and the MR ratio. Based on this idea, practicable films having an ultra-thin free layer could not be obtained at all. The reasons are mentioned below.

First, regarding the bias point, when Hs is extremely reduced by the use of the ultra-thin free layer, as in the film (2) of Comparative Case 2, the best bias point could not be

realized even though the current magnetic field Hcu is reduced, if the pinned layer stray magnetic field is large. The advantage of the structure of the film (3) is that, when the free layer is thick, or that is, when Hs is relatively large, then the best bias point having been once obtained depends little on the sense current. However, when the free layer in the film constitution of (3) is much reduced, it is naturally impossible to realize the best bias point. In other words, when the thickness of the free layer in the film constitution of (3) is reduced to 4.5 nanometers or smaller so as to make the free layer applicable to high-density recording systems, the bias point shall be shifted to the plus side.

To verify the fact, the calculated bias point data of the film constitution are shown in Table 3.

Table 3

Bias Point in Film of Comparative Case 3

MR height	NiFe 5 nm	NiFe 3 nm
0.3 μm	86 %	108 %
0.5 μm	83 %	104 %
0.7 μm	81 %	100 %

Hin for the data calculation is 10 Oe. As in Table 3, it is understood that the bias point in the film constitution of Comparative Case 3 is naturally shifted to the plus side even when the thickness of the NiFe film therein is 5 nanometers, and the film constitution is not well designed. In this, the

bias point is much more shifted to the plus side when the thickness of the free layer of NiFe is thinned to be 3 nanometers.

Fig. 13 is a conceptual view showing the determinant factors for the bias point in Comparative Case 3. As illustrated, since the current magnetic field Hcu only is reduced while Hpin is still large, no bias point is obtained at all in the region where the free layer is thick. Specifically, since the best bias point appears at the site where the total sum of the current magnetic field Hcu, the interlayer coupling magnetic field Hin and the pinned layer stray magnetic field Hpin is zero, the film designing of such that the current center is made nearer to the free layer while only the current magnetic field is made zero, as in the constitution of (3), is quite meaningless.

The second problem with the constitution of (3) is that the film (3) could not have high MR ratio necessary for high-density recording. Specifically, in the constitution of (3), since a diffusion-preventing layer of a material having a relatively high resistance is put between the high-conductivity layer and the free layer, the film (3) could not enjoy the spin filter effect for MR, such as that in U.S.P. No. 5,422,591 noted above, when the free layer is an ultra-thin one. In the region where the free layer has a thickness of at most 4.5 nanometers and where the present invention is